NASA STTR 2006 Phase I Solicitation

T6.02   Predictive Numerical Simulation of Rocket Exhaust Interactions with Lunar Soil

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One of the major challenges routinely faced at the Kennedy Space Center's launch and landing sites is to prevent hardware damage from the blasts associated with launching spacecraft. This includes the prediction of the aerodynamics and vibro-acoustics of rocket plumes in the launch environment, the reduction of high velocity ejection of materials by the rocket plume, and protection of the surrounding hardware from these effects. This will be a greater challenge at extraterrestrial spaceports. When a spacecraft lands on the Moon, surrounding hardware may be damaged and contaminated by the high velocity spray of eroded soil particles, and the landing spacecraft may be affected by an upward spray along the reflection planes between multiple engines. On lunar spaceports, the blast protection infrastructure must be constructed (in part) using in-situ materials, such as a berm made with lunar soil. There are a number of mission scenarios that will be different than the Apollo experience and that cause the erosion problem to be more significant. Thus, this needs to be assessed in hardware and architecture design.

The lunar soil erosion theory developed during the 1940's and 50's did not include some of the relevant physics and as such it does not allow us to quantitatively predict the blast effects (with sufficient confidence) for missions that include multiple spacecraft landing in close vicinity to one another on the Moon. Without these predictions, it is currently not possible to develop adequate blast mitigation and protection technologies. To obtain better predictions, the Kennedy Space Center desires the development of a software tool that numerically predicts the plume interactions with the soil for rockets landing or launching on the Moon, including the erosion rates and trajectories of ejected particulate matter.

Innovations are sought, resulting in the development of a software package to improve the prediction of lunar blast dynamics. The difficulties in developing a flow code to predict these effects include the unique lunar environment, the difficulty in solving flow physics from first principles around discrete particle assemblages, the large spatial scale of the flow features compared to the vast number of lunar soil particles within that region, and the need to parameterize the erosion of soil to produce realistic predictions (although realistic benchmarking experiments of lunar erosion are difficult to perform terrestrially). In recent years, researchers have been making significant progress in understanding the interactions of particle assemblages with fluids. Emphasis shall therefore be placed on the research effort extending this progress toward correctly describing the physics of the gas/soil interactions.